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PROJECT VANGUARD REPORT NO. 15
PROGRESS THROUGH MARCH 15, 1957

[UNCLASSIFIED TITLE]

Project Vanguard Staff

April 2, 1957

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PREVIOUS PROJECT VANGUARD REPORTS

Project Vanguard Report No. 1, "Plans, Procedures, and Progress" by the Project Vanguard Staff, NRL Report 4700 (Secret), January 13, 1956

Project Vanguard Report No. 2, "Report of Progress" by the Project Vanguard Staff, NRL Report 4717 (Confidential), March 7, 1956

Project Vanguard Report No. 3, "Progress through March 15, 1956" by the Project Vanguard Staff, NRL Report 4728 (Confidential), March 29, 1956

Project Vanguard Report No. 4, "Progress through April 15, 1956" by the Project Vanguard Staff, NRL Report 4748 (Confidential), May 3, 1956

Project Vanguard Report No. 5, "Progress through May 15, 1956" by the Project Vanguard Staff, NRL Report 4767 (Confidential), June 2, 1956

Project Vanguard Report No. 6, "Progress through June 15, 1956" by the Project Vanguard Staff, NRL Report 4800 (Confidential), June 28, 1956

Project Vanguard Report No. 7, "Progress through July 15, 1956" by the Project Vanguard Staff, NRL Report 4815 (Confidential), July 27, 1956

Project Vanguard Report No. 8, "Progress through August 15, 1956" by the Project Vanguard Staff, NRL Report 4832 (Confidential), September 5, 1956

Project Vanguard Report No. 9, "Progress through September 15, 1956" by the Project Vanguard Staff, NRL Report 4850 (Confidential), October 4, 1956

Project Vanguard Report No. 10, "Progress through October 15, 1956" by the Project Vanguard Staff, NRL Report 4860 (Confidential), November 4, 1956

Project Vanguard Report No. 11, "Progress through November 15, 1956" by the Project Vanguard Staff, NRL Report 4880 (Confidential), December 3, 1956

Project Vanguard Report No. 12, "Progress through December 15, 1956" by the Project Vanguard Staff, NRL Report 4890 (Confidential), January 16, 1957

Project Vanguard Report No. 13, "Progress through January 15, 1957" by the Project Vanguard Staff, NRL Report 4900 (Confidential), February 7, 1957

Project Vanguard Report No. 14, "Progress through February 15, 1957" by the Project Vanguard Staff, NRL Report 4910 (Confidential), March 12, 1957

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PREFACE

This report is intended as a general summary of the progress on Project Vanguard during the indicated period. Hence, minor phases of the work are not discussed to a great extent, and technical detail is kept at a minimum. It is hoped that the information here presented will be of assistance to administrative and liaison personnel in coordinating and planning their activities, and as a guide to the current status of the project. Material of a more technical nature will be published from time to time in separate reports which will be announced in subsequent monthly progress reports.

PROBLEM STATUS

This is an interim report; work on the problem is continuing.

AUTHORIZATION

NRL Problem A02-90

Manuscript submitted March 27, 1957

THE LAUNCHING VEHICLE

CONFIGURATION AND DESIGN

Analysis of the data from the REAC study of structural feedback* indicates the structure of the Vanguard vehicle is adequate for all conditions of static and dynamic loading. Three factors contribute to the reduction in the bending moment obtained from the initial hand computations: (1) a more exact determination of the contribution due to controls noise, (2) a downward revision of the wind gust specification, and (3) a refinement of analysis permitting redistribution of assumptions which were over-conservative.

The reduction in controls noise resulted from closed-loop studies of TV-2 component hardware with desk REAC simulation of the vehicle dynamics. The amplitude of engine oscillation at 4 cps was measured as 0.05 degree, whereas earlier estimates based on open-loop information had indicated an amplitude of 0.2 degree. From the refined REAC study, it was determined that the forward controls path in closed-loop combination with the elastic structure feedback path would cause engine oscillation at 2.7 cps rather than at the first mode frequency of 4 cps. The sharp gradient of the curve relating the allowable amplitude of engine oscillation to the frequency of oscillation raises the allowable deflection. The net result lowered the bending moment at the first-stage inter-tank area for the condition of maximum dynamic pressure to a maximum value of 40,000 inch-pounds.

The downward revision of wind gust specification initiated by NRL† defines the gust load to be superimposed on the trajectory loads as a step gust of 20 fps true velocity acting over a vertical distance of 300 feet. The bending moment associated with this gust load is 60,000 inch-pounds. The earlier hand computations had indicated a 140,000 inch-pound bending moment for the original 40-fps gust load plus a 50,000 inch-pound load associated with engine deflection. Thus the gust dynamic loading has been lowered by a factor of three.

The conservatism in the initial study assumed an angle of attack of 5.5 degrees and the sudden application of a hard-over engine deflection of 4.5 degrees. Since the refined REAC study included the angle of attack resulting from the application of a wind gust in the computation of wind loading, the angle of attack requirement was reduced to 4 degrees with a corresponding bending moment of approximately 40,000 inch-pounds. The engine deflection required to compensate for this static angle of attack is 1.2 degrees which is equivalent to a bending moment of 90,000 inch-pounds. In addition to this 1.2-degree deflection there is an engine deflection of 0.3 degree resulting from the controls response to the gust loading. These two deflections were subtracted from the 4.5-degree-hard-over engine transient, reducing it to 3 degrees with a corresponding bending moment of 230,000 inch-pounds. The assumption of a hard-over engine transient is introduced purely as a conservatism and does not correspond to any expected disturbance.

The bending moment resulting from the simultaneous application of controls noise, specified wind disturbance, a 4-degree angle of attack, and a 4.5-degree engine deflection is 450,000 inch-pounds. The allowable bending moment is 530,000 and 500,000 inch-pounds for TV-2 and the SLV configurations, respectively.

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*P.V.R. No. 14, p. 5
†P.V.R. No. 14, p. 1

The strain gages have been removed from TV-2 because the telemetry sampling rate is not sufficient to provide the information needed: a suitable switch with an adequate sampling rate is not available, and individual telemetering channels for each strain gage cannot be provided. Reliance is being placed on accelerometers installed at several locations in the vehicle to provide the desired information on bending moments.

A paint pattern to aid in the optical determination of vehicle attitude (Fig. 1) has been given to the Glenn L. Martin Co. (GLM). This pattern, to be located directly below the first-stage inter-tank section, will employ a flat black on a flat white background to provide the best compromise between day and night image contrast. The pattern will be evaluated on TV-2 through the TV-3 backup.

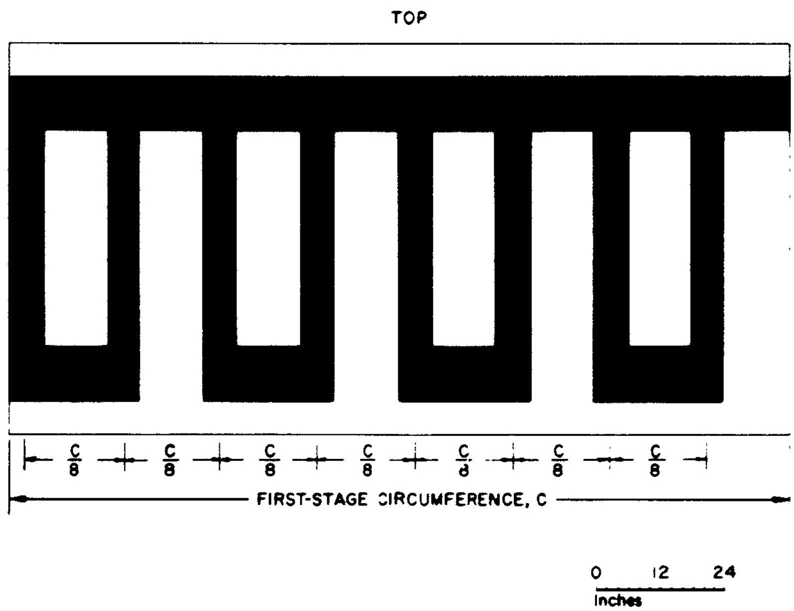

Fig. 1 - Paint pattern to be evaluated as aid to optical attitude determination

In order to test the bonding properties of the tape used to attach the von Karman vortex spoilers to the vehicle and check the aerodynamic qualities of the scupper which will strip them off after launch, a simplified low-speed wind-tunnel test has been performed by GLM. The preliminary results indicate that the present scupper design will cause spoiler separation at speeds near 150 fps rather than the expected 100 fps. Since this difference in vehicle velocity represents only about 7 seconds of flight time, and the drag due to the spoilers is relatively small in this low speed range, the scupper design appears to be satisfactory for spoiler separation and will be used on TV-2

PROPULSION

First Stage

Thirty-five more firings have been made for the purpose of evaluating modifications of the first-stage motor to eliminate chamber burnouts.* The efforts have been concentrated on testing and improving the modified chamber which has three equispaced copper fins brazed to the inner chamber wall between each normal steel helix fin; this design shows considerable promise. Several minor injector modifications have also been tested and a preliminary design "freeze" has been established for the next few engines.

The chambers tested were of the finalized configuration (equispaced copper fins) with the recent modification of chrome plating on the gas side of the inner wall. Burnouts and scoring were virtually eliminated by the use of this design. The injector configuration has been temporarily "frozen" at an interim design which involves countersinking the liquid side of the injector holes in the four outer rings. This design yields repeatable performance without extreme score-producing characteristics, but the performance is just under the minimum specifications. An improved injector design is being investigated and should be tested in the near future to determine its burnout susceptibility; preliminary tests and evaluation of this improved injector indicate improved performance can be expected.

In view of the improvement of this combination with respect to burnout, an engine was assembled and tested at the Malta Test Station. This engine is expected to pass acceptance tests and to be delivered as the next X-405 powerplant (P-2)† to be used for TV-2. The delivery is currently scheduled for 1 April 1957.

A recent inspection of the first delivered powerplant (P-1)‡ has disclosed rusting within the fuel manifold. This condition precludes attempting to fire the engine until the rust is removed. In view of the present schedule of the improved (P-2) powerplant, P-1 will not be returned for rust removal until some later date when substitution of an improved motor body and injector can be made.

Added quality control measures are being taken to insure delivery of hardware which compares well to the design configuration, e.g., optical comparison of the injector holes. It is reported that once quality control assures accurately fabricated hardware, repeatability and improvement of performance can be expected.

The thrust structure problem previously encountered** appears to have been eliminated by a redesign of the thrust leg welds and by improved testing procedures. A combination tension-compression "fishtail" weld design is currently being used on all structures. Load proof tests are now being made in both compression and tension to eliminate handling and "cold" test failures. Complete X-ray and dye-check tests are being performed to check for weld penetration and cracks. Painting of the thrust structure is being replaced by an anodized coating as the protective, to permit observation of any incipient cracks which may enlarge after assembly.

*P.V.R. No. 14, p. 1
†Since the engines heretofore designated P-2, P-3, and P-4 were unacceptable, these numbers will be reassigned to the improved engines.
‡P.V.R. No. 10, p. 5
**P.V.R. No. 12, p. 4

Further data from NACA on the lox-fluorine investigations* indicate that the performance of the first-stage engine can be significantly increased without substantial changes in hardware. In about 30 firings of a water-cooled scaled-down (5000-pound thrust) X-405 thrust chamber, the average specific impulse with lox-fluorine as the oxidizer was about 10 seconds higher than with lox. Moreover, if JPX (about 50 percent kerosene and 50 percent unsymmetrical dimethyl hydrazine) were used as the fuel instead of kerosene, a still higher gain could be realized. The theoretical specific impulses (I_{sp}) for the three propellant combinations under consideration are:

Combination	I_{sp}
lox-kerosene	258 seconds
fluorine-lox-kerosene	270 seconds
fluorine-lox-JPX	277 seconds

There is an additional advantage which would obtain from the use of JPX: its optimum mixture ratio with lox-fluorine as the oxidizer is approximately the same as the mixture ratio of the present lox-kerosene combination, 2.2. The ratio for lox-fluorine-kerosene on the other hand, is about 2.6, which would necessitate a change in the tank ratio and in the propellant loading procedures.

There appear to be no insurmountable problems with respect to heat flux with the lox-fluorine oxidizer. The modified G.E. engine configuration has an estimated heat-rejection margin of about 20 percent, while the maximum increase in heat flux considered possible with the lox-fluorine oxidizer is about 10 percent; the NACA data actually indicate a decrease from 1.37 to 1.15 BTU/in^2-sec, although this may reflect some fortuitous circumstances. The change in heat flux resulting from the use of JPX as a fuel is expected to be minimal or negligible.

In view of the foregoing information and the favorable results of their own tests on static and moving oxidizer seals, GE has made a proposal for a full-scale experimental program with the modified X-405 engine. It is estimated that a flyable engine employing the new combination could be delivered not more than two months after a successful full-duration firing.

The first-stage burnout velocity increases which are attainable by using lox-fluorine-kerosene and by using lox-fluorine-JPX are about 450 fps and 600 fps, respectively.

Second Stage

The Aerojet General second-stage tank and thrust chamber assemblies comprising the prequalification test unit have been assembled in a test stand for prequalification firings at the Sacramento facility. This unit is the same as the deliverable units except that the Mod 34 injector is low in performance. The prequalification firings started during the latter part of this report period, but regulator failures and a fire caused by a fuel line failure have delayed these tests. The fuel line failed in a weld near the helium sphere and the fire which resulted burned the magnesium skirts and caused other minor damage. The damage is now being repaired and tests are to be resumed within a few days.

*P.V.R. No. 10, pp. 5-6; No. 11, p. 4; No. 12, p. 5; No. 13, pp. 2-3; and No. 14, p. 2

It had been reported recently that the Aerojet thrust chambers have some leakage through welds along the walls. Apparently only one chamber had been tested for leaks, however, and five chambers which have since been tested do not leak.

The last of the 15 second-stage thrust chambers has now been completed. Five thrust chamber assemblies including injector, valves, plumbing, etc., have been completed to date, and two more injectors are ready for installation. The chamber nozzle closure tests have continued in order to determine the optimum material thickness; meanwhile, on the basis of previous test results, a 24ST aluminum diaphragm of 0.006 - 0.007 inch thickness has been chosen for the prototype design.

Early during this report a tentative decision was made to use a Futurecraft regulator in the helium system. This regulator was selected because of its simplicity of operation and light weight. However, failures during the prequalification tests made it more advisable to use the Aerojet regulator previously intended for the system in the prequalification unit and propulsion unit no. 1. The Aerojet regulator appears to be reliable – no failures in 12 tests conducted – but its weight, complexity, and nonfunctioning before firing are unattractive features. Further tests are to be performed on the Futurecraft regulator to determine its usability.

There are now seven tank assemblies completed, three by the Cromer Co. and four by Aerojet. One assembly is presently being subjected to pressure cycle tests.

Third Stage

Grand Central Rocket Company

The Grand Central Rocket Company (GCR) has completed the prequalification testing of solid propellant rockets for TV-1. Two units have been accepted and delivered to AFMTC (see page 21); the weights were 431.8 and 433.4 pounds. These units fit on the spin table except for a slight interference with the brackets holding the spin rockets.

The GCR has now improved the integrity of its nozzle closure* by means of better gluing and strengthening of the plug. Previously the plug blew out prematurely after ignition. The improved plug is expected to last for 0.55 second, i.e., until the chamber pressure has risen above the critical value. Since the resolution of this problem, the prequalification test program has been completed. Six of the firings were statistical to obtain acceptance data. The specific impulses were 239, 242, 240, 243, 239, and 243 seconds. The ignition delay was less than 1 second for a temperature range of 20° to 130°F. The data obtained in the acceptance tests indicate that the principal deviations from the specifications are as follows:

	Specification Value	Present Value
Burnout weight	53 lb	56 lb
Final loaded weight	433 lb	434 lb
Velocity increment	14,182 fps	13,600 fps
Specific impulse	245 sec	239 sec

*P.V.R. No. 14, p. 4

GCR is proposing an improvement program intended to reduce the inert weight in order to compensate for low specific impulse of the propellant. These improvements are expected to bring the velocity increment up to specification value.

Allegany Ballistics Laboratory

The Allegany Ballistics Laboratory (ABL) conducted no firings during this report period. The insulation and joint failures reported last month* caused ABL to submit a proposal for a new rocket chamber. This fiberglass-reinforced plastic chamber will have the insulation molded into the case rather than separately inserted, and the propellant will be case-bonded. The junction of the aft end closure and the cylindrical body will also be redesigned for better sealing. The following program has been proposed:

> ABL will manufacture six cases of the new design.
>
> Two of these cases should be loaded with propellant for test firing by 5 March 1957. (Because of a proof test failure this has been delayed four weeks.) The remaining four cases should be loaded only after the successful testing of the first two. If all six of these tests are successful, ABL should be authorized to manufacture a minimum of four additional motors for proof firing under various environmental conditions. If all ten test firings are successful, the qualification test program should proceed as originally planned.

FLIGHT CONTROL

Attitude Control

The modified† SLV pitch-yaw jet system has been installed in the dynamic mockup at the GLM plant and several dynamic tests have been made. However, helium leaks have forced the temporary shutdown of controls testing, and evaluation of this new circuitry is not complete. Preliminary bench tests of the system indicated satisfactory operation with no evidence of the overloading with large inputs which had been observed in the previous dynamic tests.

The Vickers magnetic amplifiers have been revised to include (1) an adjustable notch filter which can be centered at the second mode of elastic structural resonance, and (2) a lag circuit which will provide a satisfactory phase margin at the first mode of resonance as required for stabilization of the elastic structure feedback loop. The amplifiers have been reworked and are ready for acceptance tests.

The controls test equipment for TV-2 and TV-3 has been received from the Polarad Corporation. The equipment for TV-2 is being checked out, while the TV-3 equipment has been returned for revision. This was necessitated by design changes which arose as a result of difficulties experienced in the controls testing of TV-0, e.g., the incorporation of an independent ground.

Flight Program and Staging

The first of the programmers has now been shipped by Designers for Industry, Inc., and the first of the integrating accelerometer coasting time computers has been shipped by Air Associates, Inc.

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*P.V.R., No. 14, p. 3

†P.V.R., No. 14, p. 4

Studies of launch stand clearance have revealed the possibility of mechanical interference between the aft vehicle structure and the stand. Both the inherent misalignment characteristics of the vehicle and external disturbances at the time of final alignment in the stand have been considered. Misalignment arises from manufacturing tolerances and includes (1) displacement of gyro axes relative to the vehicle first-stage axis due to interstage mating tolerances, (2) displacement of the center of gravity of the vehicle from the vehicle axis, and (3) lateral or angular thrust displacement due to engine and gimbal characteristics. External disturbances include (1) the thermal bending of the vehicle from solar heating, (2) bending of the vehicle from wind disturbances, and (3) error in transit sighting during the alignment process. When the cumulative effects of these factors have reached a certain magnitude as determined by computer studies, interference exists. The problem has been solved by a 90-degree rotation of the follow-up potentiometers mounted on the hydraulic actuators and by a revision of the launch stand design. This revision provides for a relocation of the stand pads to raise the vehicle a maximum of 12 inches. The revised pad structure may be a hinged arm, counterweighted to retract from the vehicle path at the time of lift-off.

A REAC study of first-stage separation has been completed by GLM. Review of this study indicates that mechanical interference occurs when extreme variations are assumed for the thrust decay of the first-stage engine. A principal item in the study is determination of the reactive force of the second-stage engine blast on the first-stage lox dome. The impingement pressure data obtained from test runs at Aerojet* are being used to evaluate this reactive force. Unfortunately, however, the Aerojet impingement data are only adaptable for obtaining pressure in the transition compartment before separation. Evaluation of the REAC study is being continued to determine (1) the probability of thrust decay variations extreme enough to cause interference, and (2) the validity of the assumed reactive force on the first stage due to the second-stage engine blast.

A test was conducted simulating separation of electrical connectors† (first-second stage separation) at various altitudes. The test setup permitted the simulation of the first-stage battery and its connected loads and the subsequent paralleling of the second-stage battery with the lag system. Altitude separation was simulated by the rapid disconnecting of the plugs from their receptacles in an evacuated chamber. One test was made at a simulated altitude of 70,000 feet, and another at the minimum pressure obtainable in the chamber. Visual observation of the separation indicated no arcing or damage. Inspection of the plugs and pins, and examination of oscillographic records substantiated these observations. Although the tests did not simulate exactly the anticipated environment of actual stage separation, these results are considered satisfactory assurance that paralleling of the batteries prior to separation, and subsequent separation can be accomplished successfully.

Dynamic mockup tests of TV-1 third-stage spinup and separation† are still in progress at GLM. These tests are being conducted primarily to verify the proper action of the spin and separation circuitry.

A plastic nose cone designed for use on the vehicles from TV-4 through the SLV's is being prepared for tests. Evaluation of the nose-cone jettison mechanism will be completed after jettison tests have been conducted with the plastic nose cone; previously, tests were made on an aluminum cone.‡

*P.V.R. No. 14, p. 6
†P.V.R. No. 13, p. 6
‡P.V.R. No. 12, p. 8

THE SATELLITE

Work on the narrow-band random noise test equipment at NRL has now progressed to a point where this test may be offered as a substitute for the sinusoidal tests used to establish the adequacy of a satellite design.

Work is continuing on the installation of the wide-band random noise test equipment which will be used for the final design tests and tests of flight units. It is expected that this equipment will be ready for use in time to conduct the first satellite final design test, scheduled to start 8 April 1957.

In order to determine the vibration environment of the satellites during powered flight, numerous vibration measurements have been made during static firings. The following preliminary information is based upon data obtained during 28 test firings of third-stage motors at the Grand Central Rocket Company.

1. Some type of "resonant burning" of the motor tends to appear about 16 seconds after the development of thrust, causing a change in the character and level of vibration at the satellite mounting point. Nearly sinusoidal accelerations at frequencies of 1400 - 1600 cps and 10- to 40-g momentary amplitudes appear, primarily in the direction transverse to the motor axis. The condition persists for 5 to 10 seconds during which the frequency shifts downward. No evidence of the resonance has been found in any of the other measurements taken during firings.

2. Vibration during the rest of the motor burning time appears substantially random in amplitude, with spectral energy distributions extending to the 5-Kc upper frequency limit of recording instrumentation. The levels are generally below 0.05 g^2/cps, with a statistical distribution among firings which is currently being analyzed.

3. Acoustic levels in the order of 140 db (referred to 10^{-16} watts/cm^2) have been consistently observed during the test firings.

In light of the above, the currently suggested satellite vibration specification is still considered satisfactory.

CONFIGURATION AND DESIGN

20-Inch Satellites

A recent revision of the requirements for the NRL Lyman-alpha experiment necessitates moving the ion chamber from its location on the equator and adding a second ion chamber. The two chambers are now located 180 degrees from the solar cell at 45 degrees north and 45 degrees south latitude on the skin of the sphere between antennas 2 and 3 (Fig. 2). The change requires reworking all satellite shells and manufacturing additional ion-chamber mounting pieces. Modification drawings have been made, and one unit is now being modified for test purposes.

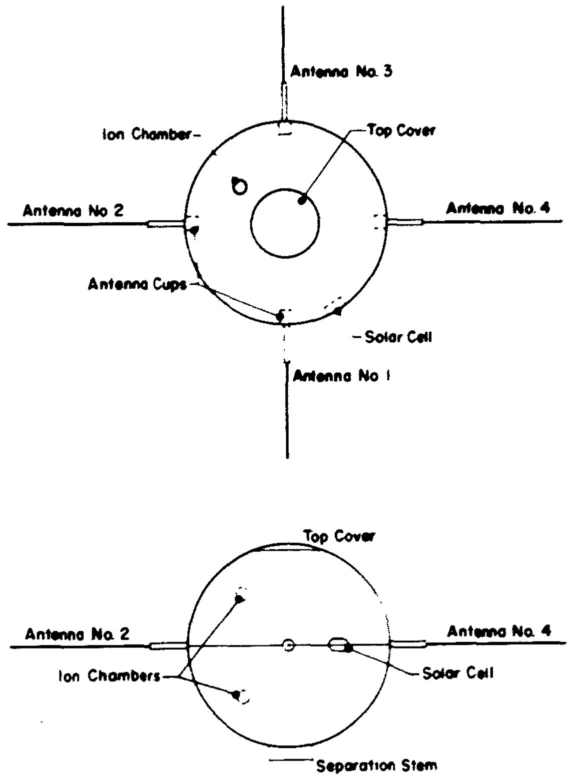

Fig. 2 - New locations of NRL Lyman-alpha ion chambers

Brooks and Perkins have delivered 20-inch magnesium satellite units 7, 8, 9, 10, and 11; these are now being inspected, weighed, pressure tested, and fitted with internal packages. Silicon monoxide coating of these units is being delayed pending the results of thermal tests on units 2 (uncoated), 5, and 6.

Magnesium unit no. 1* has now been accelerated to 78 g steady state, with an internal package weight of 12 pounds 4 ounces and antennas simulated by adding equivalent weights at the pivot points (the centrifuge will not accommodate the antennas). No failures of any kind occurred.

Magnesium unit no. 4 has been vibration-tested with an internal package weight of 10 pounds 6 ounces to determine the structural adequacy of the main base Kel-F support which has been reduced in cross section to retard thermal conduction,* and also to determine the effects of mounting the erosion gages near the base in the high-stress area. Both the Kel-F support and the erosion gage proved adequate. The Kel-F support was also

*P.V.R. No. 14, p. 7

compression tested to yield, which occurred at 2300 pounds with a deflection of 0.022 inch and a resulting set of 0.0025 to 0.0028 inch.

It now appears feasible to dynamically balance the 20-inch satellites to within 0.5 ounce-inch.

Vibration tests have been made on the aluminum prototype of the cosmic radiation satellite for the State University of Iowa.* Several failures occurred after many tests and were attributed to fatigue; the unit is being repaired and will be tested further.

Preliminary design information has been received from the University of Wisconsin on a 20-inch satellite for their planned experiment to determine the radiation balance of the earth. The configuration is similar to the State University of Iowa cosmic ray satellite, but the internal can may be longer. Preliminary design layouts of this satellite are being made.

6.44-Inch Satellites

Magnesium 6.44-inch satellite units 5, 6, 7, and 8 have been received and the internal Kel-F parts have been fitted. These units are now ready for silicon monoxide coating. Units 9, 10, 11, and 12 are scheduled for delivery early in April.

The separation stem area of the 6.44-inch satellites has been reduced and vibration studies indicate that the modified units have adequate strength. Dynamic balancing of the modified units to within 0.1 ounce-inch appears to be feasible.

INSTRUMENTATION

Two features have been added to the Minitrack satellite telemetering transmitter; the new schematic is given in Fig. 3.

A capacitor-coupled low-level coaxial output has been added to provide 1 milliwatt of local oscillator power to the command receiver. Resistor R_3 has been added to reduce the cw power level from 60 to 20 milliwatts to conserve battery power during the "tracking only" phase of the orbit. This feature reduces the battery drain by more than half for 99 percent of the time.

Satisfactory operation of the transmitter at high temperatures has been extended from 50° to 60°C by the addition of a heat-sink transistor holder. The transistor is clamped in a brass ring which is mounted in an aluminum block 1/8 inch thick. The brass ring and the aluminum block are electrically isolated by a Teflon sleeve of 0.010 inch thickness. The thermal conductivity from the transistor to the chassis has reduced the temperature differential from 17°C to 7°C at 200 milliwatts collector dissipation. Since the transistor shell is the collector lead and therefore the high rf side of the tank circuit, the transistor holder capacitance is part of the tank circuit capacitance. An equivalent capacitance, approximately $8\mu\mu f$, has been subtracted from the circuit.

The modified transmitter, before potting, is shown in Fig. 4.

The thermal conductivity of the Ecco Foam used for potting is very low, and in a vacuum the transmitter chassis temperature rises above the ambient temperature owing to the transistor dissipation. Fingers have therefore been added to the chassis to provide good thermal contact with the internal package rods.

*P.V.R. No. 14, p. 8

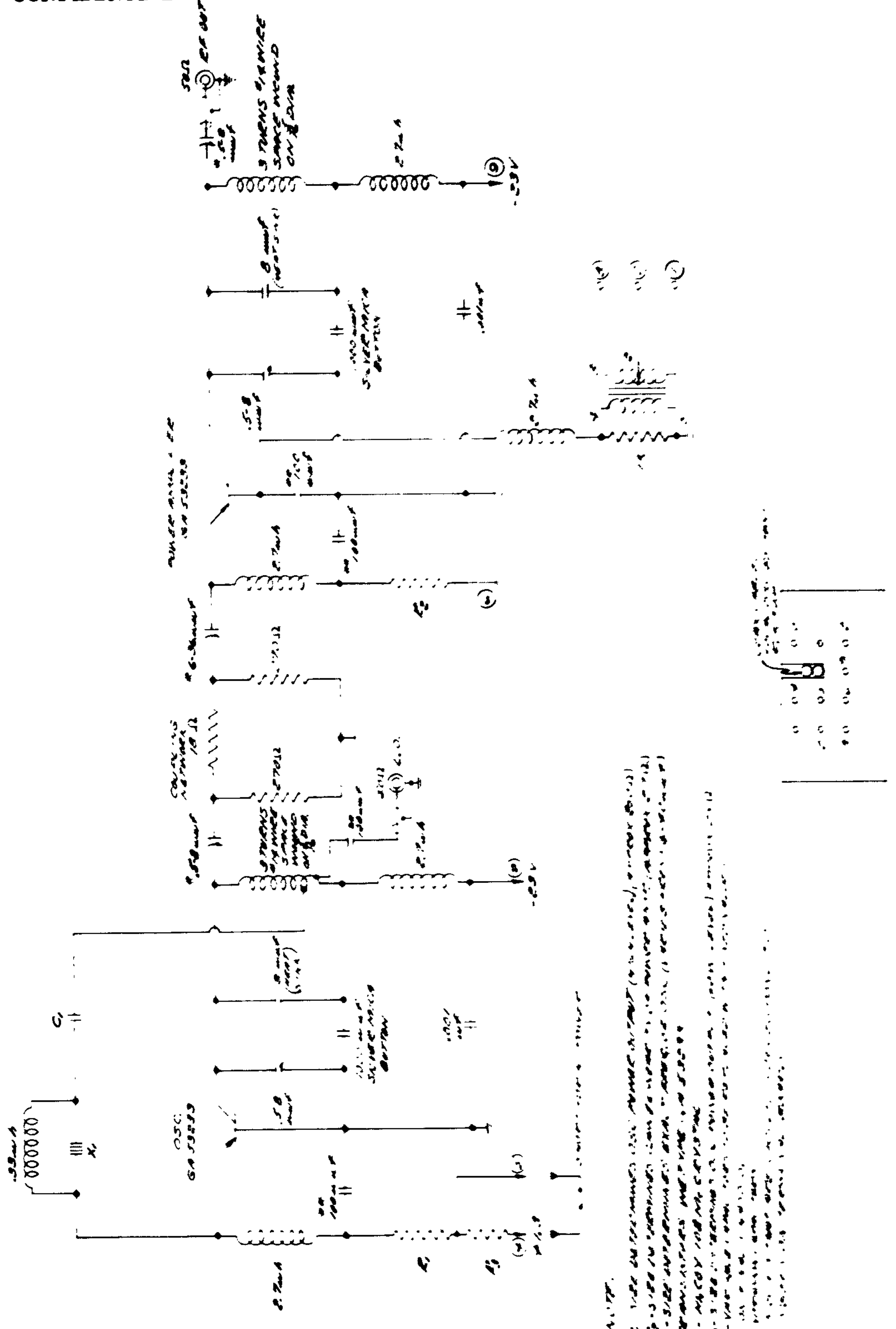

Fig. 3 - Modified Minitrack satellite telemetering transmitter circuit

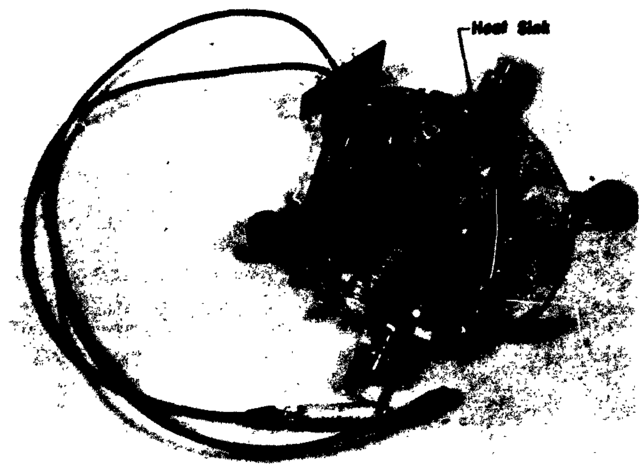

Fig. 4 - Modified Minitrack telemetering transmitter before potting

Environmental gages in the NRL satellite have been tested through the telemetering transmitter, and the signals were readable to about 1 part in 500. However, all measurements will be impaired somewhat by the parallel resistance network used to limit the dynamic range of the channels (necessary because of the Lyman-alpha time requirements). The exact extent of this impairment will depend critically on the reading error experienced with flight signal-to-noise ratios.

An attempt is being made to determine how far down into the noise the telemetered signal from the satellite can be read and to what accuracy. Recordings have been made in a completely assembled satellite with modulation from all channels. The transmitter signal was attenuated in steps during the recording until the noise completely obscured the modulation. Without any filtering, reliable measurements could be made when the signal-to-noise ratio had dropped to 2. Filtering and averages of repeated readings should allow further improvements in accuracy.

A complete overall check has been made on the proposed satellite telemetering system: signals transmitted by a satellite package were received, recorded and reproduced on film with satisfactory results. Control consoles* are now being built for incorporation in the system. Ground equipment for use at WSPG during the forthcoming tests of satellite instruments in Aerobee-Hi flights 40 and 41 has been readied and is being installed in a trailer.

During these flights, monitoring of the output of the meteor collision amplifier is desired. An amplifier and pulse stretcher have been built which will allow this output to be applied to the conventional rocket telemetering system.

A preliminary training manual has been written for ground-station operating personnel, describing pertinent components of the telemeter system, their operation, and repair. The first group of ground-station personnel has been given training in equipment operation and

*P.V.R. No. 14, p. 10

maintenance. Tests of different manufacturer's magnetic tapes have been made and analyzed, and the choice of a preferred tape has been made.

An impulse generator which imparts a small impact to the satellite shell has been built. It is planned to use this generator to test the sensitivity of the meteoritic collision amplifier.

The Army Signal Corps Engineering Laboratories, in the program of design and development of satellite solar power systems, have concluded the irradiation damage study on silicon solar cells. Preliminary appraisal of the results indicates that the solar converter cells will not be seriously affected by the anticipated radiation levels in outer space. Cycle life tests on nickel-cadmium batteries continue; to date hermetically sealed cells have survived well over 2000 cycles at normal temperature and pressure, and over 600 cycles in vacuum at room temperature. Work is continuing on cementing processes, efficiency measurements, and possible filtering methods.

THEORY AND ANALYSIS

The requirement for rapid reduction of Minitrack data does not permit the application of time corrections to these data. It is therefore necessary that the time signals broadcast by WWV be uncorrected during the tracking of a satellite. It is not vital that the time signals be perfectly correct, but only that they establish a uniform time scale for a period of two to four weeks. In view of this, NRL has made the following requests to the Bureau of Standards: (1) that no step adjustments be made in the time ticks from WWV during the appropriate operational periods, and (2) that the frequency of WWV remain as close as possible during these periods to its initial value, irrespective of what that value may be. The Bureau of Standards has replied that these requests can be met, and that no difficulty is anticipated. The implementation of this procedure will involve telephone or telegraph communications between the Vanguard Computing Center and WWV to confirm the beginning and end of the proposed "condition constant."

For the purpose of estimating the number of times per day that a satellite in various orbits could be observed from various stations, it is desirable to have a picture of the geographical sub-satellite tracks for a day's interval. Such tracks have been computed for the 12 typical cases of circular orbits having 10, 12, 14, and 26 revolutions per day, and inclinations to the equator of 32.5, 35, and 37.5 degrees. The computed tracks have been completely plotted on Mercator world charts.

For the purpose of planning the launching times to avoid orbits having high percentages of time in sunlight, which would harm delicate apparatus, such as transistors, the percentage of time in sunlight has been computed for 3 orbits: (1) circular at 200 miles, (2) perigee at 200, apogee at 800 miles, and (3) perigee at 200, apogee at 1500 miles.

By using a theoretical solution and assuming the conditions that the apogee is toward, away from, or 90 degrees from the sun, the percentages of time in sunlight have been computed for solar declinations of 0, ±10, ±20, and ±23-1/2 degrees for all times of day, for the aforementioned orientations of the major axis (computations for the 90-degree apogee case are not yet completed). To display this information, charts having a uniform size and coordinate plan, showing contours in date and launch-time of 65, 75, 85, and 100 percent sunlight time have been completed. Additional charts showing variations of these contours for 2 weeks nodal regression have also been completed. The accuracy of these charts has been checked by a graphical optical device and found to be satisfactory. Charts for each of the solar declinations 0, ±10, ±20, and ±23-1/2 degrees, showing sunlight percentages versus firing time, have been completed.

Computation of the sunlight percentage for apogee 90 degrees from the sun has been completed for the largest orbit for solar declinations of ±10 and ±20 degrees. The resulting charts of sunlight percentage versus firing time also show the curves for apogee toward and away from the sun. Such charts allow interpolation for any orientation of perigee. Computation of the orientation of perigee at all firing times at solar declinations of 0, ±10, ±20, and ±23-1/2 degrees is now underway.

A typical chart, for the condition of 1500-mile apogee, 200-mile perigee, and apogee away from the sun, is given in Fig. 5.

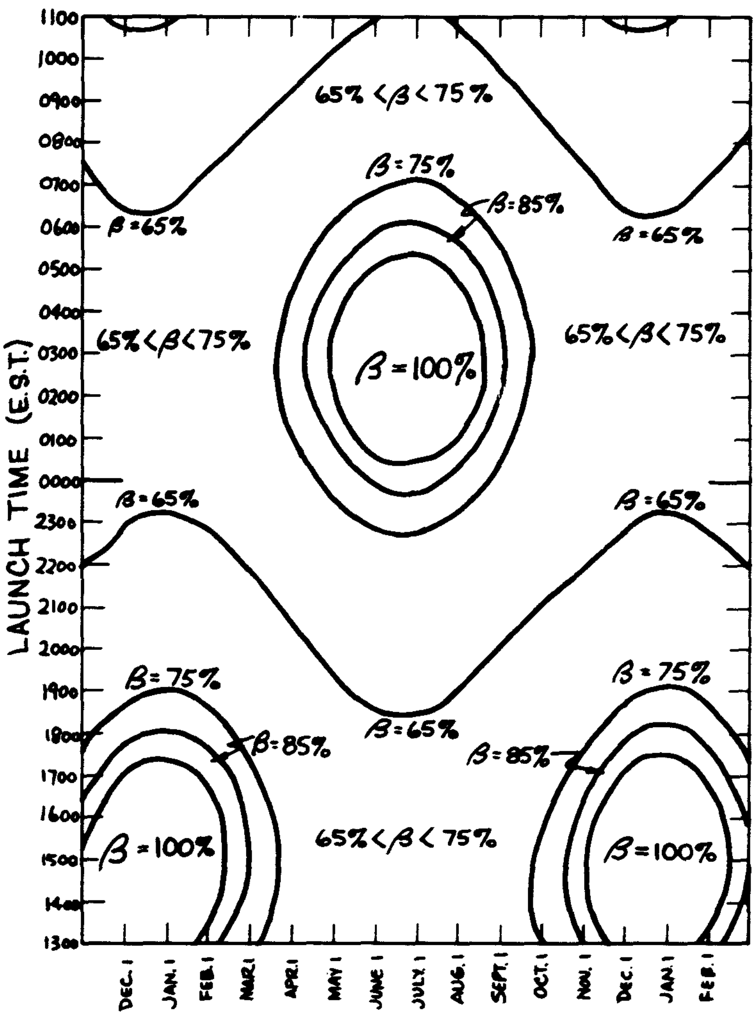

Fig. 5 - Percentage of time in sunlight for 200-1500 mile orbit, apogee away from sun

ELECTRONIC INSTRUMENTATION

TELEMETERING

PPM/AM Systems

One ppm/am vehicle telemetering transmitter and calibrator are ready for shipment to AFMTC for TV-4. Two additional transmitters have been received from the Spivey Co.; one of these has been rejected and the other shipped to AFMTC as a spare for TV-1. Four more transmitters and five spare rf transmitting heads are expected by 22 March.

To date, 13 of the 25 ppm/am calibrators contracted for have been delivered by the Leemath Co. The contract called for delivery of all 25 by 4 September 1956.

Further testing of the 12 video recorder film magazines and 30 take-up reels from the Wilkes Precision Instrument Co.* has resulted in the return of 5 magazines and 19 reels to the company for reworking. Redelivery of these items is expected by 1 April.

PWM/FM Systems

Tests of the modified pwm/fm vehicle telemetering transmitter* have disclosed interference difficulties with the transistorized power supply, and excessive temperature rise in the transistors. Efforts are being made to overcome these problems. It was found that removal of the internal fan was helpful: this reduced the rise above ambient temperature by 1/2 during a 15-minute test. It is also proposed to eliminate the filament dropping resistors by adding a filament winding to the transformer in the transistorized power supply. This will save approximately 50 watts now lost in heat dissipation and cut down the transistor heat arise to about 2/3 of its present value.

A still newer package design, based on removal of the fan and motor, is under consideration. This package would be smaller by 100 cubic inches and lighter by about 1 pound than the present modified package, and would represent a total weight reduction of 39 percent over the original package which contained a heavy dynamotor and an oversized rf power amplifier.

FM/FM Systems

The fm/fm vehicle transmitter is presently undergoing noise reduction studies.

VEHICLE TRACKING

By utilizing fixed and signal bias, it has been possible to eliminate the bias battery in the T-11 Dovap transponder. This change also results in a more nearly constant power

*P.V.R. No. 14, p. 11

output under conditions of varying line voltage and signal strength, and in a weight reduction of 2 ounces. All T-11 transponders to be used in the vehicles starting with TV-2 will be modified in this fashion; six units have been modified to date. The power transformers in six T-11 transponders have been replaced by new units which are electrically and environmentally superior to the originals. Noise studies are being conducted on the T-11 transponders in an effort to explain the Dovap noise experienced with TV-0.

Aircraft flight tests of a modified AN/DPN-19 radar beacon* have been satisfactorily completed at AFMTC. The final data are not yet available, but observations during the tests indicated the following performance:

1. Operating range: At 100 miles, the signal-to-noise ratio at the radar averaged approximately 20 db with a tail aspect and 40 db with a nose aspect; this is attributable to the pattern of the nose antenna on the aircraft. With an attenuation of 18 db in both transmitted and received signal at the radar, tracking ranges of up to 50 miles were achieved before beacon countdown (noise triggering) began. Extrapolation of these data to determine the maximum tracking range indicates that with an antenna gain equivalent to that of the nose aspect of the aircraft, a range of at least 200 miles can be obtained with this beacon.

2. Interrogation by multiple radars: Although the beacon recovery time is in the order of 75,000 yards range, it was possible to interrogate and track the beacon with up to three radars simultaneously.

The final delivery of the four C-band AN/DPN-31 radar beacons has now been made by the Hazeltine Electronics Co.;† this company modified three of these units from S-band to C-band and constructed the fourth C-band unit.

The first C-band AN/DPN-48 (XE-1) radar beacon is now undergoing environmental tests at Melpar. Changes are required in the power transformer and diode rectifiers, and in the mechanical structure of the rf head. Environmental tests are being conducted on the QK-488 magnetron to determine its suitability as a replacement for the present BL-212

A second S-band AN/DPN (XE-1) unit is also undergoing tests at Melpar. A second C-band unit still lacks a magnetron and plumbing.

RANGE SAFETY

The Connecticut Telephone and Electric Co., has constructed one AN/ARW-59 command receiver.‡ This unit is now undergoing bench tests, and two more units are under construction. This company has also completed the preliminary design drawings of the transistorized decoder to replace the KY-55/ARW now used with this receiver,** and a breadboard model is under construction.

*P.V.R. No. 13, p. 7
†P.V.R. No. 13, p. 16
‡P.V.R. No. 10, p. 19
**P.V.R. No. 14, p. 11

THE MINITRACK SYSTEM

The NRL Minitrack Training Program officially opened on 4 March, with six officers and six enlisted men in attendance. The officers will be assigned as the Officers-in-Charge of the six Prime Minitrack stations being established and operated for Project Vanguard by the U.S. Army as follows:

Capt. W. L. Hurst - Ft. Stewart, Georgia
Capt. D. K. Martin - Batista Field, Cuba
Capt. F. Clark - Quito, Ecuador
Capt. A. McPhaul - Lima, Peru
Capt. W. Frank - Antofagasta, Chile
Capt. E. Riewerts - Santiago, Chile

The six enlisted men will assist NRL personnel in the instruction of subsequent classes of the Minitrack Training Program, after which they will be assigned to station operating crews.

Precision surveying of the Blossom Point Minitrack antennas is to be completed by 22 March, after which the station will be established on a 24-hour basis to check long-term system drifts by means of frequent aircraft calibration runs. This continuous operation will go on until 19 April. At the conclusion of these runs the present bead-supported solid rf transmission lines will be replaced by the spiral dielectric type to be used at the overseas stations, and the four fine antennas will be replaced by antennas from the production supplier, the Technical Appliance Corporation. These changes are required to make the Blossom Point station identical to the final overseas Prime Minitrack stations in all respects, thus permitting the duplication and analysis of all system troubles and calibration drifts that occur at the overseas stations. These changes will be made during the period 22 April through 10 May.

Flight calibration runs using the AD-5W aircraft are now becoming more frequent as the weather clears. The method of conning the aircraft into the correct "lane" over the station by relaying actual meter indications from the ground Minitrack system to the aircraft is working very well. Since 9 March, eight successful star-field plates have been obtained containing aircraft flashing-light images for which correlative ground Minitrack data are available. On the basis of these plates, it can now be said that the calibration method that has been established will be satisfactory. Arrangements are underway for the provision of additional aircraft for the calibration of all Minitrack stations in this hemisphere.

The first complete trailer installation of a production Minitrack ground station unit will be available by 1 April at the contractor's plant (the Bendix Radio Division of the Bendix Aviation Corporation, Towson, Maryland). This unit will be subjected to intensive system tests, including a road test of the entire trailer assembly prior to delivery to NRL. The scheduled initial delivery of this unit to NRL is 20 May.

A Mark II Minitrack system has been in operation at Blossom Point continuously since 23 January, tracking the sun and radio sources in Cygnus, Cassiopeia, and Taurus. From these data a station calibration has been determined. To check this calibration, a calibration flight was made on 13 March; the data from this flight are not yet fully reduced. The star data are also being used to correlate tracking errors with sunspot activity and ionospheric disturbances.

Several experiments have been conducted at Blossom Point with motor-generator power on various types of voltage regulators to determine a suitable voltage regulator for use in the field. An experiment has also been conducted at Fort Belvoir to determine the extent of interference in this location; the Army Map Service is constructing a Mark II installation at this site. All parts orders, with the exception of a few minor items, have been placed for the two Army Map Service Mark II Minitrack ground stations. Delivery of these units to the Army Map Service, less antennas, is scheduled for 1 May. Evaluation of antennas for these units is now underway with a delivery of production antennas scheduled for about 1 June.

The contract for the Fort Stewart station was awarded on 27 February 1957. This concludes placing all stations under construction contract. In general the construction phase of the stations is ahead of schedule and free of major problems at this time. The details of funding this program between the NRL and the AMS are being concluded satisfactorily.

Astronomic observations have been completed at all sites except for the azimuth observations at Antofagasta. First-order geodetic ties for the Cuba and South America Stations have been completed.

DATA PROCESSING

TELEMETERED DATA

Two preliminary copies of the graphs for the ppm/am data telemetered from the nose cone of TV-0 have been received from the New Mexico College of Agriculture and Mechanic Arts. The final graphs and tabulated data will be delivered in the near future.

Radiation, Inc. plans on getting the digital data recording trailer of the automatic recording and reduction facility (ARRF) ready in time to record the ppm/am telemetered data at the NRL Telemetry Pad (Cape Canaveral) for the flight firing of TV-1. The interim transistorized ppm/am coder developed by NRL will be installed by Radiation, Inc. for this flight; a binary-decimal converter and other display features have been incorporated in this coder to provide ease of operation. Although the interim system for playback will not be ready until some time after the firing, an actual digital magnetic tape record of the ppm/am data will be of great value in checking the performance of the reduction portion of the ARRF system. It is expected that the pwm/fm and fm/fm portions of the data recording system will be completed in time for the flight firing of TV-2.

ORBITAL DATA

Installation of the Vanguard Computing Center in Washington by IBM is proceeding on schedule. The interior demolition work has been completed by the building contractor; the air conditioning equipment and raised floor for the IBM 704 computer are now being installed. The expected completion date for the center is June 1957.

Additional programs have been prepared and test calculations run on the 704 computer for elliptic orbit determination and prediction from sets of four observations.

THIRD-STAGE FIRING PREDICTION

The Bureau of Aeronautics has changed the shipment date of the AN/FPS-16(XN-2) radar from 30 April 1957 to 20 May 1957 from RCA, Moorestown. This delay will permit simultaneous operation of both the XN-2 and XN-1 systems at Moorestown, provided the XN-1 is placed in operation by about 15 April. The shipment date for the XN-1 is now 31 May 1957. AFMTC is arranging for direct air shipment of the XN-1 to PAFB and of the XN-2 to Grand Bahama Island. The building for the XN-2 on GBI is expected to be ready for beneficial occupancy on 30 April 1957.

The proposed mathematical formulation of the impact prediction and of the third-stage firing prediction has been completed by the RCA Service Company in cooperation with NRL. It is expected that both prediction programs for the IBM 704 computer at Cape Canaveral will be completed by 1 June 1957. It is anticipated that the AN/FPS-16(XN-1) at PAFB, the digital data transmission system from the XN-1 to the 704 computer at Cape Canaveral, and the impact prediction program will all be completed in time to provide operation of the digital impact prediction system on an experimental basis for the firing of TV-2.

RANGE OPERATIONS

All propulsion and flight control horizontal tests on TV-1 have been completed at AFMTC. Horizontal instrumentation calibration is also complete. The antenna test is about 80 percent complete and will be concluded upon the arrival of the instrumented nose cone; this is expected in the next few days.

The hangar telemetry radiation tests revealed some transmitter noise which originated in the control system inverter; this noise has now been reduced to an acceptable level.

Two inert rockets from the Grand Central Rocket Company arrived at AFMTC on 26 February, and two live rockets on 11 March. Several trial installations on the inert rockets on the spin table revealed mechanical interference between the rocket nozzle and the brackets for mounting the spin rockets. Efforts to eliminate this difficulty are underway. The receiving inspection of the live rockets has revealed some distortion of the case suspension and slight rusting at the exit flange on one unit. This inspection will be completed upon the arrival from GLM of a thrust alignment fixture, scheduled for 1 April.

The launching of TV-1 is now scheduled fcr 18 April.

CONFIDENTIAL

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